EXHIBIT 6

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(54) **CALIBRATION TECHNIQUES FOR ACTIVITY SENSING DEVICES**

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See application file for complete search history.

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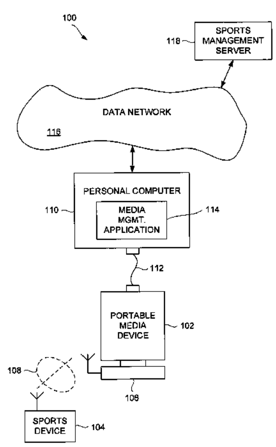
(57) **ABSTRACT**

Improved techniques and systems to calibrate an electronic device that is providing activity sensing are disclosed. The activity being sensed can, for example, correspond to walking or running by a user. In one embodiment, calibration can be performed by a portable electronic device so that activity data it receives from a remote sensor device can be more accurately processed. The improved techniques and systems to calibrate can be used to monitor, process, present and manage data captured by a remote sensor. The portable electronic device can also offer a convenient user interface that can be visual and/or audio based, customized to a particular application, user-friendly and/or dynamic. The portable electronic device can pertain to a portable media player and thus also provide media playback.

13 Claims, 14 Drawing Sheets



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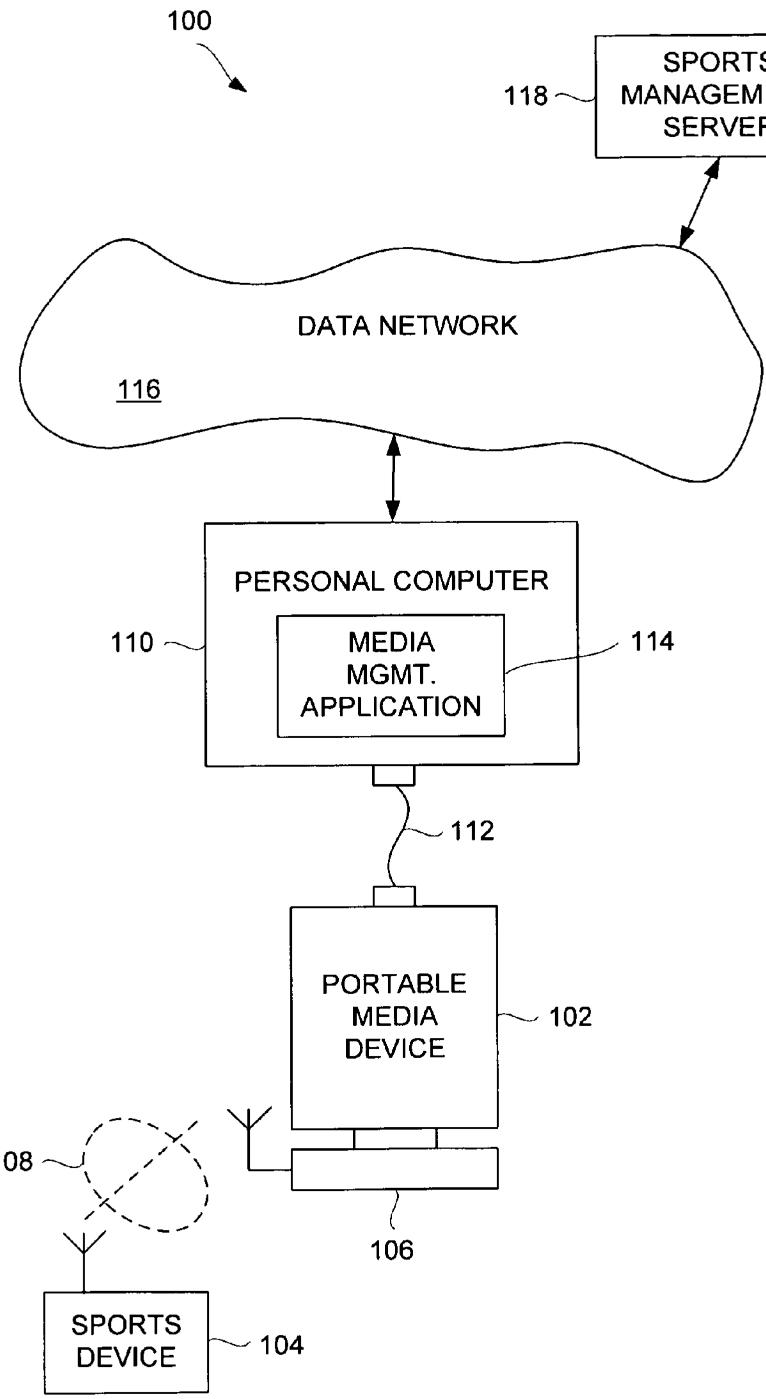
100
118
SPORTS MANAGEMENT SERVER
DATA NETWORK
116
PERSONAL COMPUTER
110
MEDIA MGMT. APPLICATION
114
112
PORTABLE MEDIA DEVICE
102
108
106
SPORTS DEVICE
104

FIG. 1

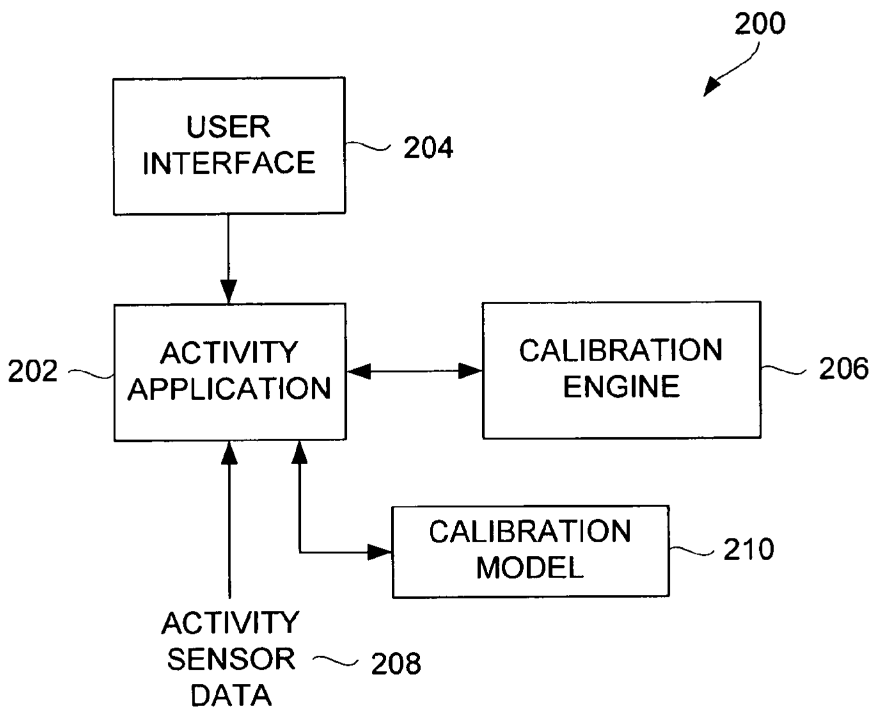
200
USER INTERFACE
204
202
ACTIVITY APPLICATION
CALIBRATION ENGINE
206
CALIBRATION MODEL
210
ACTIVITY SENSOR DATA
208

FIG. 2

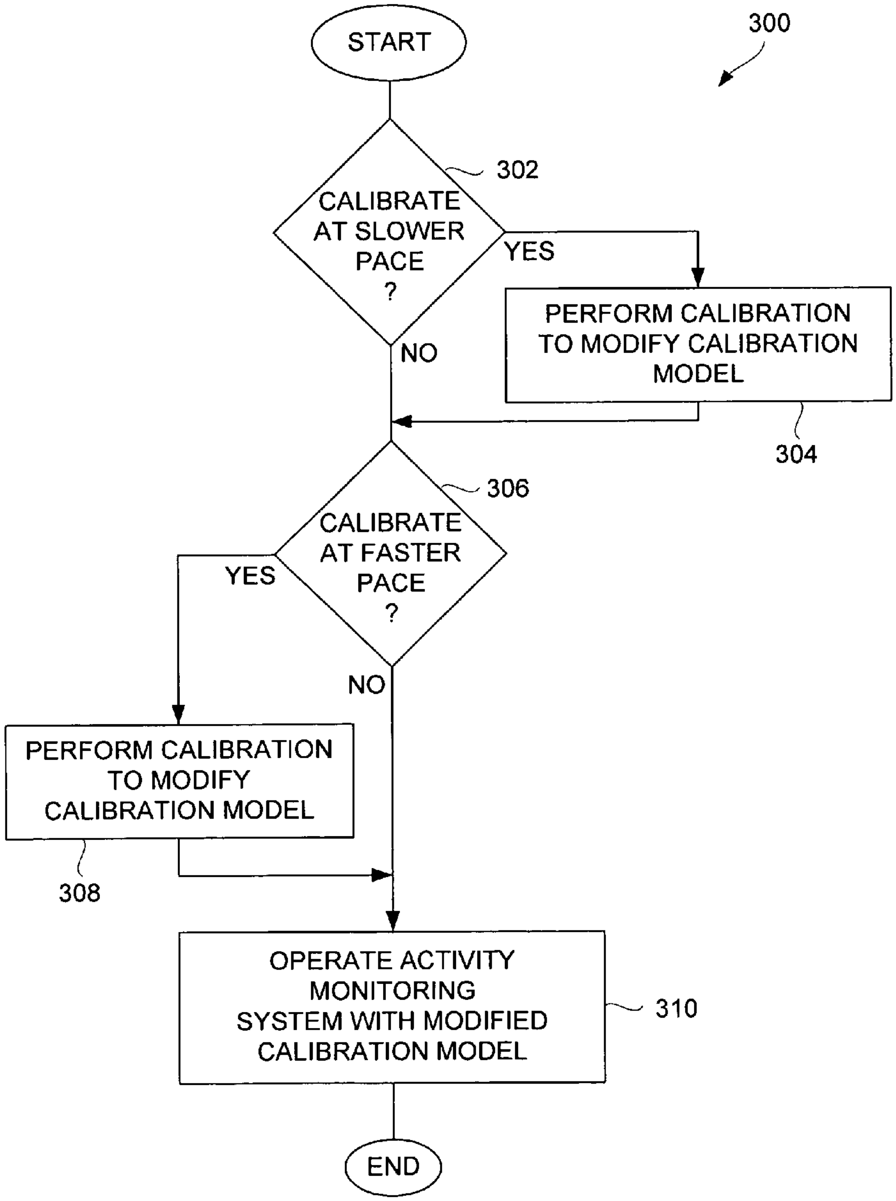
300
START
CALIBRATE AT SLOWER PACE ?
302
YES
NO
PERFORM CALIBRATION TO MODIFY CALIBRATION MODEL
304
CALIBRATE AT FASTER PACE ?
306
YES
NO
PERFORM CALIBRATION TO MODIFY CALIBRATION MODEL
308
OPERATE ACTIVITY MONITORING SYSTEM WITH MODIFIED CALIBRATION MODEL
310
END

FIG. 3

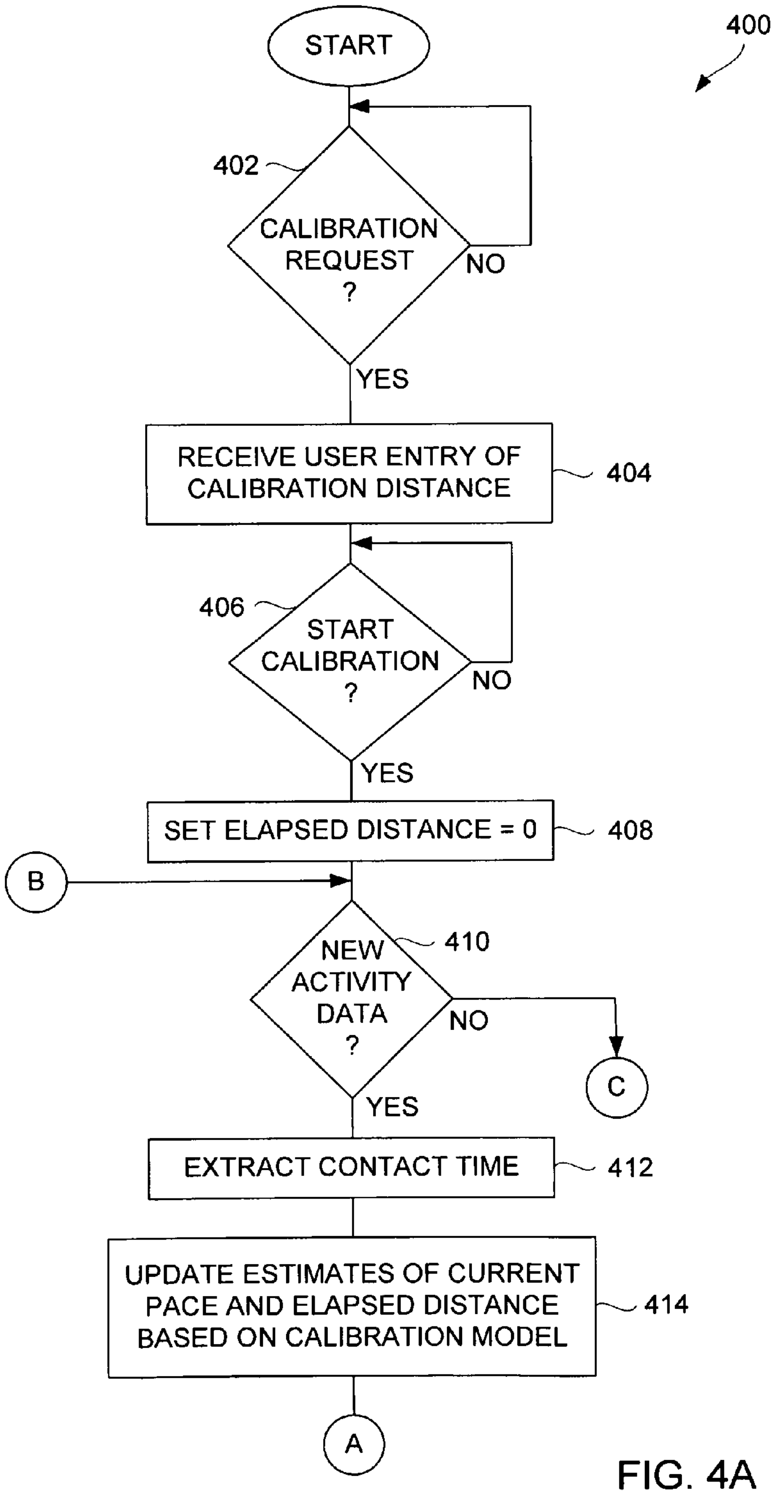
400
START
402
CALIBRATION REQUEST ?
NO
YES
RECEIVE USER ENTRY OF CALIBRATION DISTANCE
404
406
START CALIBRATION ?
NO
YES
SET ELAPSED DISTANCE = 0
408
B
NEW ACTIVITY DATA ?
410
NO
C
YES
EXTRACT CONTACT TIME
412
UPDATE ESTIMATES OF CURRENT PACE AND ELAPSED DISTANCE BASED ON CALIBRATION MODEL
414
A

FIG. 4A

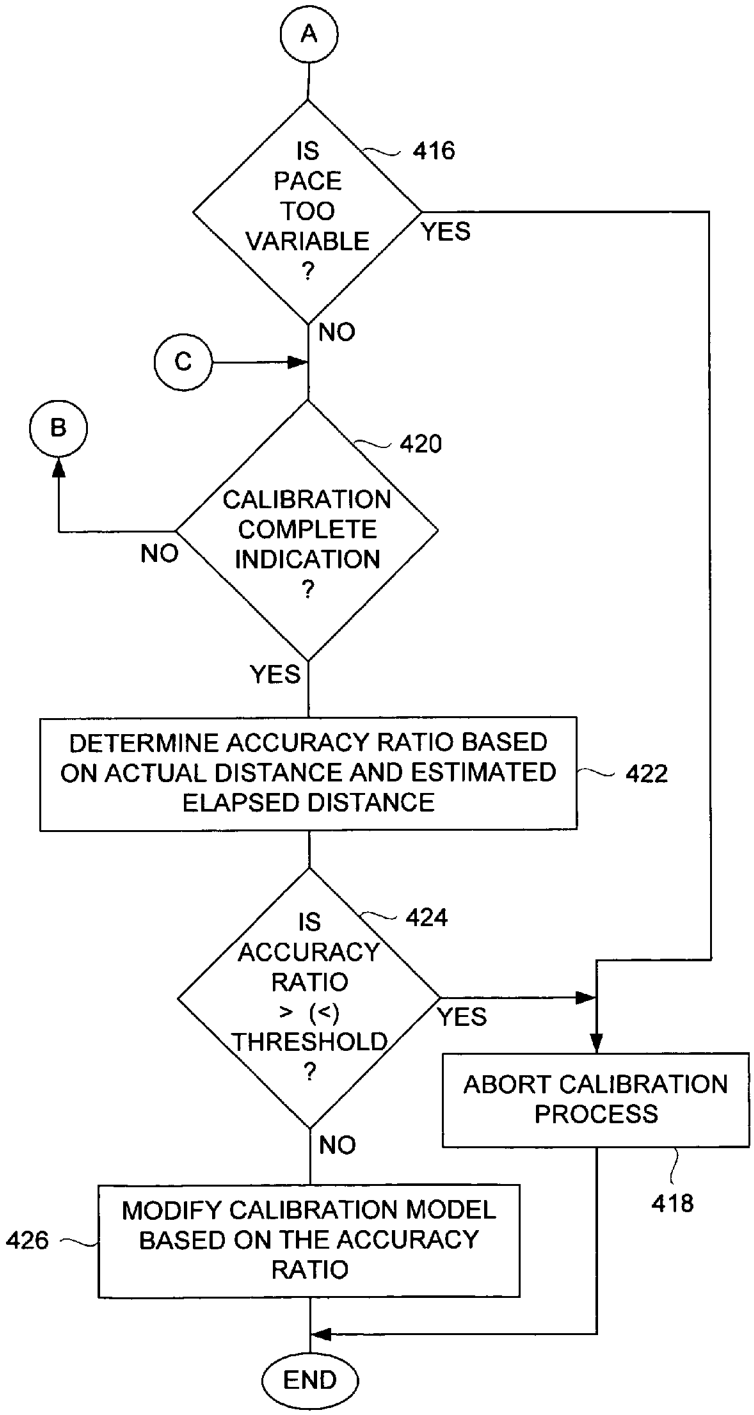
A
IS PACE TOO VARIABLE ?
416
YES
NO
C
B
420
CALIBRATION COMPLETE INDICATION ?
NO
YES
DETERMINE ACCURACY RATIO BASED ON ACTUAL DISTANCE AND ESTIMATED ELAPSED DISTANCE
422
424
IS ACCURACY RATIO > (<) THRESHOLD ?
YES
ABORT CALIBRATION PROCESS
NO
418
426
MODIFY CALIBRATION MODEL BASED ON THE ACCURACY RATIO
END

FIG. 4B

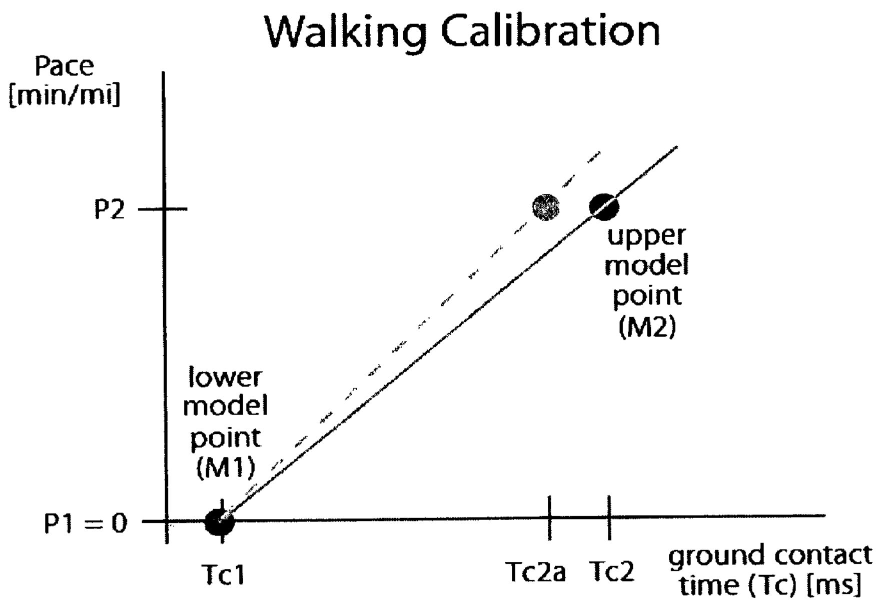
Walking Calibration
Pace [min/mi]
P2
P1 = 0
lower model point (M1)
upper model point (M2)
Tc1
Tc2a
Tc2
ground contact time (Tc) [ms]

FIG. 5

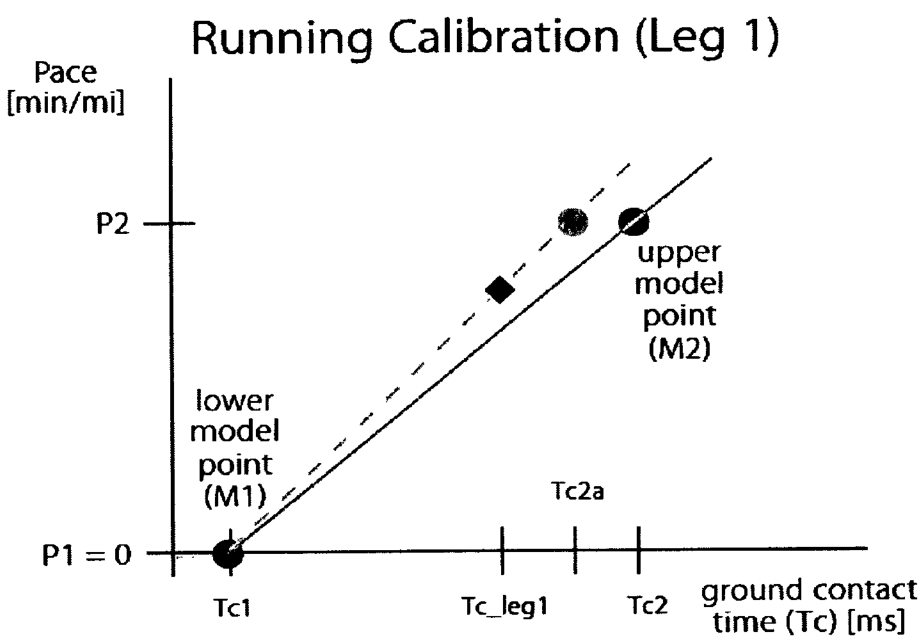
Running Calibration (Leg 1)
Pace [min/mi]
P2
P1 = 0
upper model point (M2)
lower model point (M1)
Tc2a
Tc1
Tc_leg1
Tc2
ground contact time (Tc) [ms]

FIG. 6A

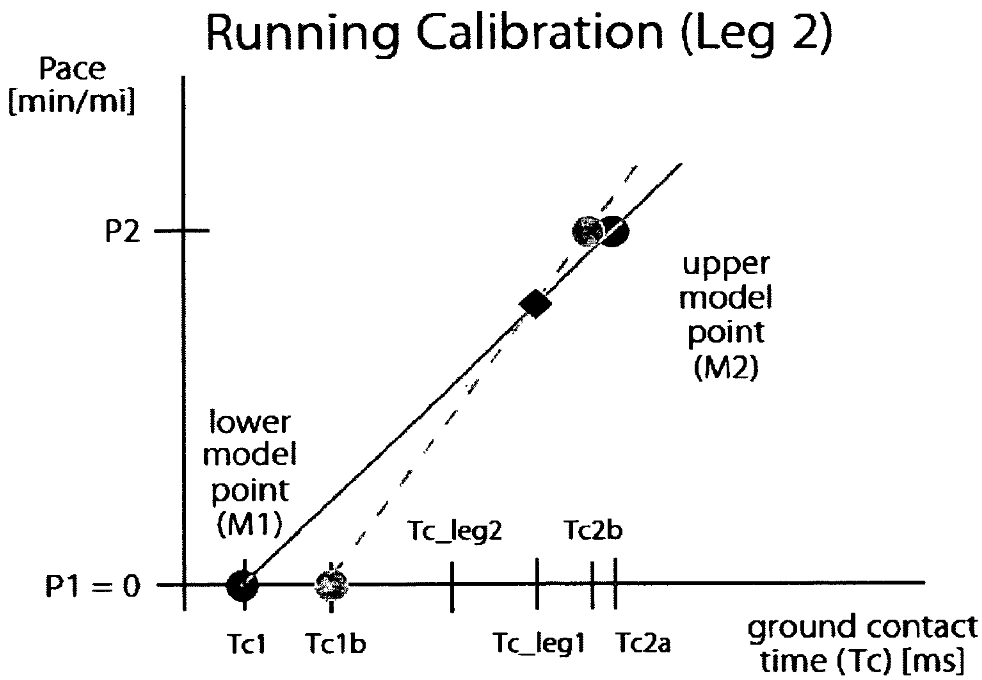
Running Calibration (Leg 2)
Pace
[min/mi]
P2
upper
model
point
(M2)
lower
model
point
(M1)
P1 = 0
Tc_leg2
Tc2b
Tc1
Tc1b
Tc_leg1
Tc2a
ground contact
time (Tc) [ms]

FIG. 6B

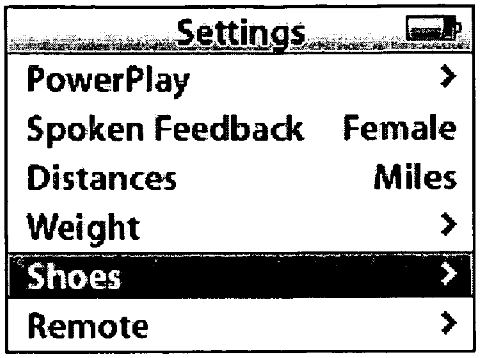

FIG. 7

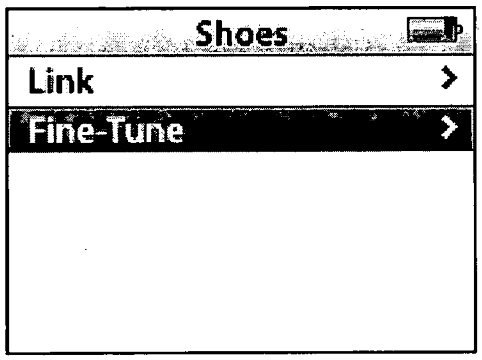

FIG. 8

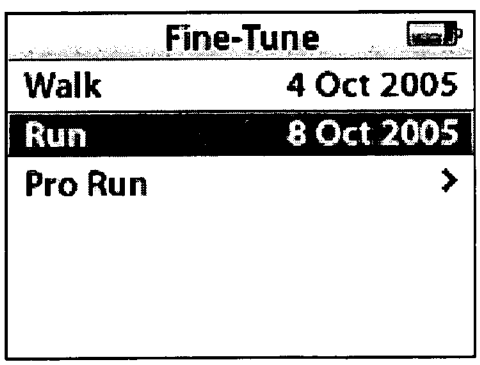

FIG. 9

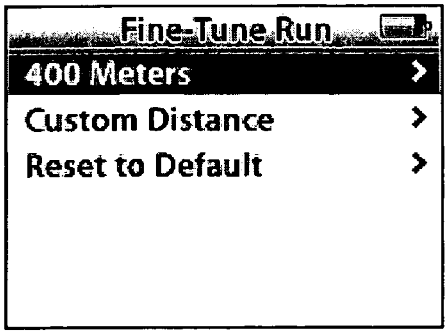

FIG. 10

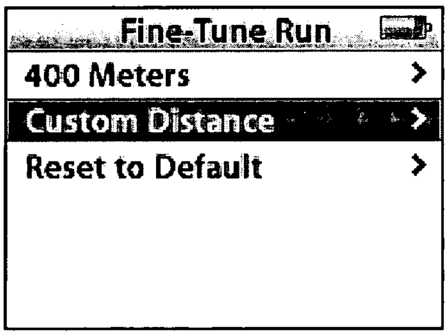

FIG. 11

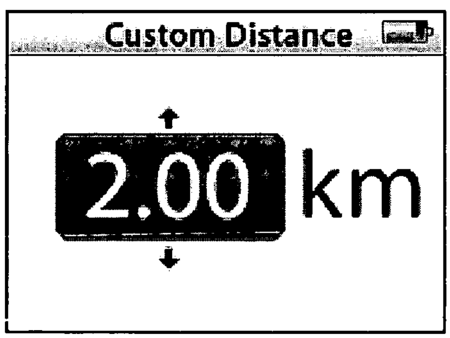

FIG. 12

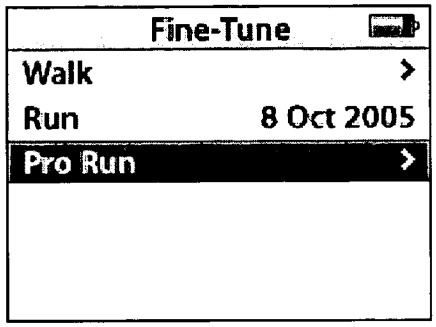

FIG. 13

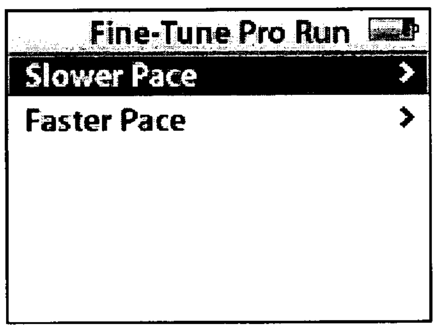

FIG. 14

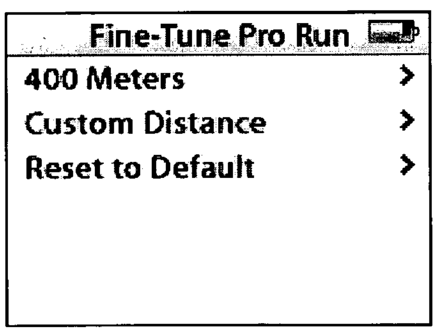

FIG. 15

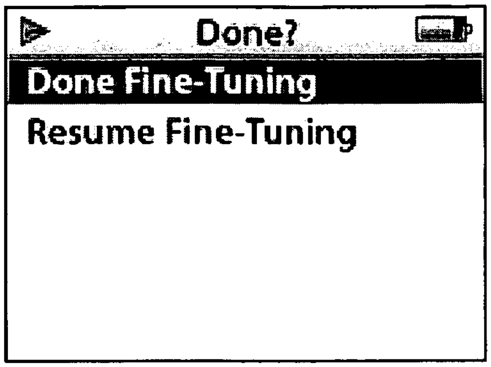
Done?
Done Fine-Tuning
Resume Fine-Tuning

FIG. 16

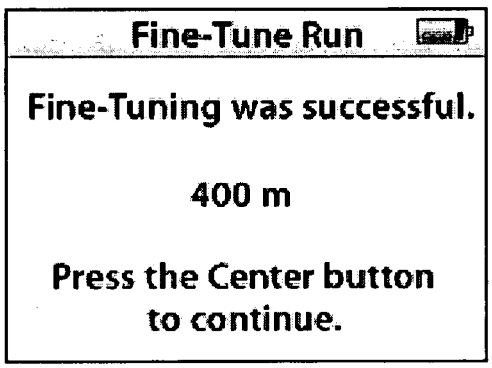
Fine-Tune Run
Fine-Tuning was successful.
400 m
Press the Center button
to continue.

FIG. 17

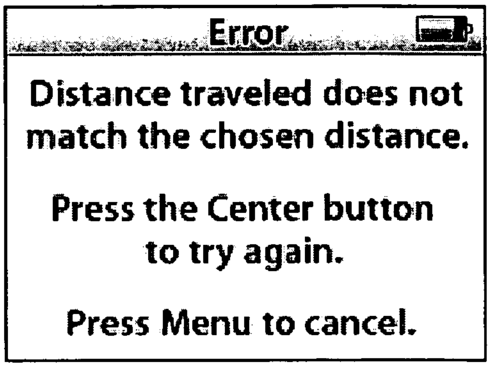
Error
Distance traveled does not match the chosen distance.
Press the Center button to try again.
Press Menu to cancel.

FIG. 18

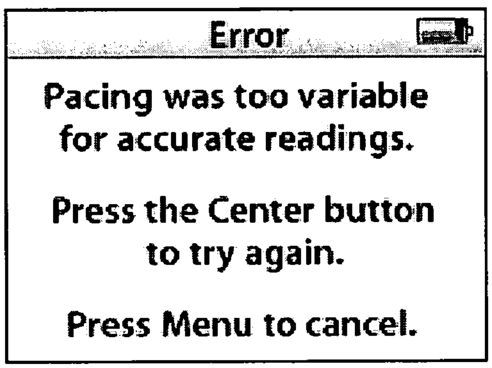
Error
Pacing was too variable for accurate readings.
Press the Center button to try again.
Press Menu to cancel.

FIG. 19

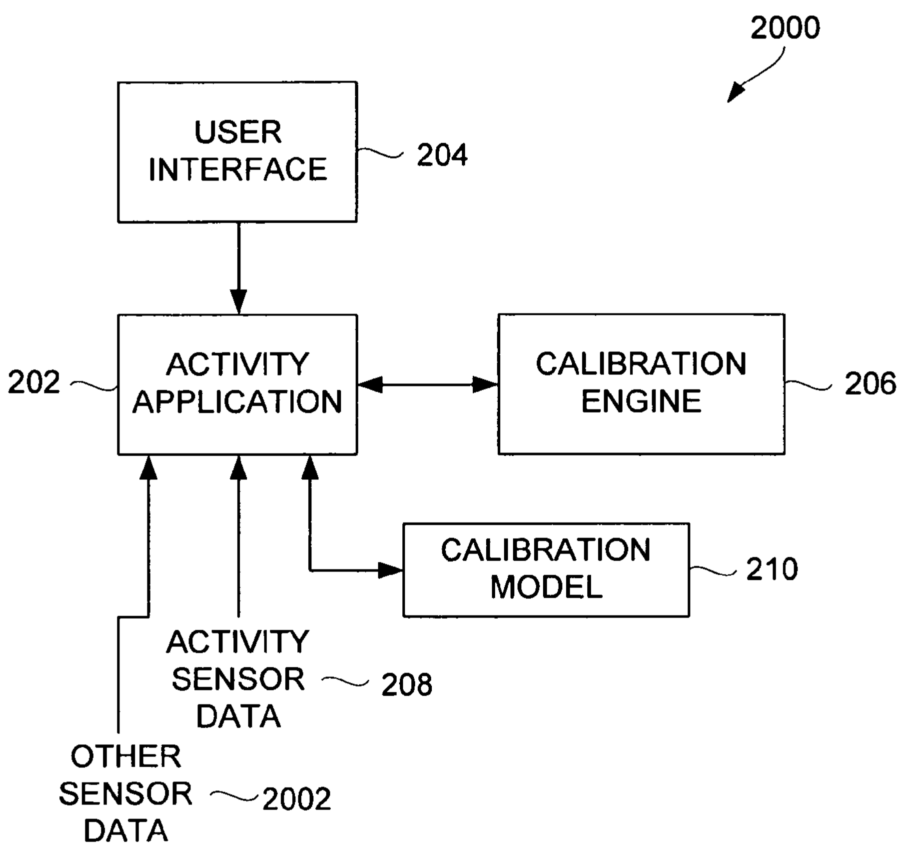
2000
USER INTERFACE
204
202
ACTIVITY APPLICATION
CALIBRATION ENGINE
206
CALIBRATION MODEL
210
ACTIVITY SENSOR DATA
208
OTHER SENSOR DATA
2002

FIG. 20

CALIBRATION TECHNIQUES FOR ACTIVITY SENSING DEVICES

CROSS-REFERENCE TO RELATED APPLICATIONS

This application claims the priority benefit of U.S. Provisional Patent Application No. 60/802,889, filed May 22, 2006, and entitled "ACTIVITY MONITORING SYSTEM", which is hereby incorporated by reference herein.

This application is also related to: (i) U.S. patent application Ser. No. 11/566,072, filed Dec. 1, 2006, and entitled "ACTIVITY MONITORING SYSTEM"; (ii) U.S. patent application Ser. No. 11/439,521, filed May 22, 2006, and entitled "COMMUNICATION PROTOCOL FOR USE WITH PORTABLE ELECTRONIC DEVICES," which is hereby incorporated by reference herein; (iii) U.S. patent application Ser. No. 11/419,737, filed May 22, 2006, and entitled "INTEGRATED MEDIA JUKEBOX AND PHYSIOLOGIC DATA HANDLING APPLICATION," which is hereby incorporated by reference herein; and (iv) U.S. patent application Ser. No. 11/439,523, filed May 22, 2006, and entitled "PORTABLE MEDIA DEVICE WITH WORKOUT SUPPORT," which is hereby incorporated by reference herein.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to activity monitoring and, more particularly, to activity monitoring by portable electronic devices.

2. Description of the Related Art

A media player stores media assets, such as audio tracks, that can be played or displayed on the media player. One example of a portable media player is the iPod® media player, which is available from Apple Computer, Inc. of Cupertino, Calif. Often, a media player acquires its media assets from a host computer that serves to enable a user to manage media assets. In managing media assets, a user can create playlists for audio tracks. These playlists can be created at the host computer. Media assets within the playlists can then be copied to the media player. As an example, the host computer can execute a media management application to acquire and manage media assets. One example of a media management application is iTunes® produced by Apple Computer, Inc.

Portable media players, such as MP3 players, are able to play music for users often via earphones or a headset. Typically, portable media players are dedicated to playing media. Lately, media players have been integrated into mobile telephones as well as personal information managers (or digital personal assistants). However, many users of portable media players utilize their media players in the context of exercising, such as at the gym or while running outdoors. Unfortunately, however, portable media players are not designed to assist the users in the context of their exercising. Although portable media players can play music for the users, there is traditionally no capability to provide any non-media information to the user.

One existing approach is to use a wristwatch including GPS technology to track distance of runs, but such lacks the ability to provide media playback. While GPS may not require a calibration operation, GPS technology itself is unable to provide high precision monitoring and is dependent on being able to interact in a wireless manner with satellites.

Another existing approach is a speedometer system that includes a watch worn on a user's wrist and a small foot worn device on the user's shoe. The speedometer system can provide the user with information concerning speed, pace, distance and calories while running or walking. The speedometer system requires that the user perform one or more calibration operations to enhance accuracy. The calibration operation requires that the user run on a track or treadmill for an accurate distance. Such calibration operations are not only burdensome on its users but also can often lack accuracy.

Recently, a MP3 player has been enhanced to support wireless communications, through a Bluetooth module, with a wireless speed and distance sensor that is coupled to the shoelaces of the user's shoe. The wireless speed and distance sensor operates as a pedometer and can wirelessly transmit data to the MP3 player. Such a system permits interaction between a MP3 player and a pedometer, which are conventionally separate devices. This system also requires that the user perform one or more calibration operations to enhance accuracy. Such calibration operations are not only burdensome on its users but also can often lack accuracy.

Regardless, there remains a need for improved accuracy of sensing systems for use in or with portable media players or other electronic devices so that users are able to monitor their exercise.

SUMMARY OF THE INVENTION

The invention relates to improved techniques and systems to calibrate an electronic device that is providing activity sensing. The activity being sensed can, for example, correspond to walking or running by a user. In one embodiment, calibration can be performed by a portable electronic device so that activity data it receives from a remote sensor device can be more accurately processed.

The improved techniques to calibrate can be used by a portable electronic device to monitor, process, present and manage data captured by a remote sensor. The portable electronic device can also offer a convenient user interface that can be visual and/or audio based, customized to a particular application, user-friendly and/or dynamic. The portable electronic device can pertain to a portable media player and thus also provide media playback.

The invention can be implemented in numerous ways, including as a method, system, device, apparatus (including graphical user interface), or computer readable medium. Several embodiments of the invention are discussed below.

As a method for calibrating an activity monitoring system associated with a user, one embodiment of the invention includes at least the acts of: providing the activity monitoring system with default calibration data; performing a first calibration to produce first modified calibration data, the first modified calibration data being derived from the default calibration data; and subsequently performing a second calibration to produce second modified calibration data, the second modified calibration data being derived from the first modified calibration data.

As a method for calibrating an activity monitoring system associated with a user, one embodiment of the invention includes at least the acts of: receiving a calibration request from the user; receiving an indication of a calibration distance; awaiting a calibration start indication before starting activity to be used for calibration; receiving activity data from an activity sensor associated with the activity monitoring system during the activity for calibration; estimating at least one of pace and distance based on the received activity data and an existing calibration model; awaiting receipt of a calibration stop indication; repeating the receiving and the estimating until the calibration stop indication is received; and

modifying the existing calibration model based on at least the estimated distance from the estimating and the calibration distance.

As a method for operating an activity monitoring apparatus associated with a user utilizing at least one shoe, one embodiment of the invention includes at least the acts of: receiving shoe characteristic information pertaining to the shoe; and operating the activity monitoring apparatus based at least in part on the shoe characteristic information.

As a portable electronic device, one embodiment of the invention includes at least: a user interface for providing user input to the portable electronic device and user output from the portable electronic device; a calibration model; an activity application that operates to monitor a physiological characteristic of a user of the portable electronic device, the activity application receives sensor data acquired from a remote sensor associated with the user, and the activity application processes the sensor data in view of the calibration model; a calibration engine that operates to modify the calibration model in view of a calibration activity for which sensor data from the remote sensor is acquired and processed by the activity application or the calibration engine.

As a computer readable medium including at least computer program code for calibrating an activity monitoring system associated with a user, one embodiment of the invention includes at least: computer program code for performing a first calibration to produce first modified calibration data, the first modified calibration data being derived from existing calibration data; and computer program code for subsequently performing a second calibration to produce second modified calibration data, the second modified calibration data being derived from the first modified calibration data.

As a computer readable medium including at least computer program code for calibrating an activity monitoring system associated with a user, another embodiment of the invention includes at least: computer program code for receiving an indication of a calibration distance; computer program code for awaiting a start indication before starting activity to be used for calibration; computer program code for receiving activity data from an activity sensor associated with the activity monitoring system during the activity to be used for calibration; computer program code for estimating at least one of pace and distance based on the received activity data and an existing calibration model; computer program code for awaiting receipt of a stop indication that indicates the end of the activity to be used for calibration; and computer program code for modifying the existing calibration model based on at least the estimated distance and the calibration distance.

Other aspects and advantages of the invention will become apparent from the following detailed description taken in conjunction with the accompanying drawings which illustrate, by way of example, the principles of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will be readily understood by the following detailed description in conjunction with the accompanying drawings, wherein like reference numerals designate like structural elements, and in which:

FIG. **1** is a block diagram of a sports monitoring system according to one embodiment of the invention.

FIG. **2** is an activity monitoring system for an electronic device according to one embodiment of the invention.

FIG. **3** is a flow diagram of a multi-speed calibration process according to one embodiment of the invention.

FIGS. **4**A and **4**B are flow diagrams of a calibration model improvement process according to one embodiment of the invention.

FIG. **5** illustrates a graph pertaining to walking calibration according to one embodiment of the invention.

FIGS. **6**A and **6**B illustrate graphs pertaining to running calibration according to one embodiment of the invention.

FIGS. **7-19** are exemplary screens that pertain to fine-tuning accuracy of an activity monitoring system.

FIG. **20** is an activity monitoring system for an electronic device according to another embodiment of the invention.

DETAILED DESCRIPTION OF THE INVENTION

One aspect of the invention pertains to improved techniques to calibrate an electronic device that is providing activity sensing. The activity being sensed can, for example, correspond to walking or running by a user. In one embodiment, calibration can be performed by a portable electronic device so that activity data it receives from a remote sensor device can be more accurately processed.

The improved techniques to calibrate can be used by a portable electronic device to monitor, process, present and manage data captured by a remote sensor. The portable electronic device can also offer a convenient user interface that can be visual and/or audio based, customized to a particular application, user-friendly and/or dynamic. The portable electronic device can pertain to a portable media player and thus also provide media playback.

The invention is particularly well suited for use in monitoring sports-related data, such as exercise data (e.g., run data). However, it should be recognized that the invention is not limited to sports monitoring, but instead is applicable to any type of monitoring. For example, the monitoring can be any physiological monitoring of a person, who is typically the user of a portable electronic device.

Embodiments of the invention are discussed below with reference to FIGS. **1-20**. However, those skilled in the art will readily appreciate that the detailed description given herein with respect to these figures is for explanatory purposes as the invention extends beyond these limited embodiments.

FIG. **1** is a block diagram of a sports monitoring system **100** according to one embodiment of the invention. The sports monitoring system **100** is an electronic system that enables sports related information to be acquired, stored, analyzed, presented and shared.

The sports monitoring system **100** includes a portable media device **102**. The portable media device **102** is capable of storing and playing media for its user. For example, the portable media device **102** can output (e.g., play) audio or video. The sports monitoring system **100** also includes a sports device **104**. The sports device **104** is, for example, a pedometer, a heart rate monitor, etc. The sports device **104** includes one or more sensors that acquire sports related data.

The sports device **104** also includes wireless transmission capability so that the sports related data can be transmitted to the portable media device **102**. In particular, the portable media device **102** includes a wireless interface accessory **106**. The wireless interface accessory **106** includes a wireless transceiver so that the wireless interface accessory **106** can receive the sports related data being transmitted by the sports device **104** by way of a wireless connection through a personal wireless network **108**. The portable media device **102** can receive the sports related data from the sports device **104** via the wireless interface accessory **106** and can then operate to process and store the sports related data at the portable media device **102**.

The sports monitoring system **100** also includes a personal computer **110**. The portable media device **102** can be electrically connected to the personal computer **110** by way of a cable **112**. The cable **112** can, for example, be a Firewire or USB cable. Alternatively, the cable **112** can be replaced with a wireless link. Although the portable media device **102** is not normally electrically connected to the personal computer **110**, the electrical connection, when present, facilitates information exchange between the portable media device **102** and the personal computer **110**.

The personal computer **110** includes a media management application **114**. The media management application **114**, in one embodiment, can not only manage the media assets stored on the personal computer **110**, but can also store and manage sports related data. In one embodiment, the media management application **114** can operate to cause the sports related data stored on the portable media device **102** to be copied to the personal computer **110**. Thereafter, the sports related data can be analyzed at the personal computer **110** and/or made available to the user of the personal computer **110**. In addition, the sports monitoring system **100** can facilitate the personal computer **110** coupling to a data network **116**. The data network **116** can represent a global or wide area network, such as the World Wide Web (or the Internet). When the personal computer **110** is coupled to the data network **116**, the sports related data present at the personal computer **110** can be transferred to a sports management server **118**. At the sports management server **118**, the sports related data can be further analyzed and/or processed to facilitate usefulness of the data. The sports management server **118** supports storage and analysis of sports related data from a large number of different portable media devices and/or personal computers. Hence, the sports management server **118** can also compare the sports related data from different users. The sports management server **118** can also provide a website that can be accessed by a network browser operating on the personal computer **110** or other computing device to access sports related information or other information made available via the website.

The sports monitoring system **100** can also support one or more remote controllers (not shown). A remote controller can also communicate with a portable media device **102** via the wireless interface accessory **106**. The remote controller may require it be paired or linked with the wireless interface accessory **106** or the portable media device **102**.

The sports device **104** illustrated in FIG. **1** can take a variety of different forms. In one embodiment, the sports device is a sensor-based device. One example of a sensor-based device is a pedometer.

Although the sports monitoring system **100** illustrated in FIG. **1** provides the wireless interface accessory **106** apart from the media device **102**, in another embodiment, the functionality (e.g., wireless interface) provided by the wireless interface accessory **106** can be provided by the media device **102** itself.

FIG. **2** is an activity monitoring system **200** for an electronic device according to one embodiment of the invention. The electronic device is, for example, a portable media device, such as the portable media device **102** illustrated in FIG. **1**. The activity monitoring system **200** includes an activity application **202**. The activity application **202** is a software program that operates on the electronic device. In one example, the activity application **202** can facilitate and manage workout monitoring of workouts that are performed by a user of the electronic device.

The activity monitoring system **200** also includes a user interface **204**. The user interface **204** can be utilized to provide user inputs that can be used by the activity application **202**. For example, one particular user input is a request for calibration. FIGS. **7-15**, which are discussed below, illustrate exemplary screens of a graphical user interface that can enable a user to request calibration. When the activity application **202** receives a request for calibration, the activity application **202** starts a calibration process that is performed by the activity application **202** together with a calibration engine **206**. The calibration process makes use of activity sensor data **208** that is supplied to the electronic device from an activity sensor. The activity sensor is typically separate from the electronic device. The activity sensor transmits activity sensor data **208** to the electrical device. At the electrical device, the activity application **202** can receive the activity sensor data **208**.

The activity application **202** can process the activity sensor data in conjunction with a calibration model **210**. The calibration model **210** is a stored calibration model for use by the electronic device. In one embodiment, the calibration model **210** is customized to the user of the electronic device. In addition, the activity application **202** provides processed activity data as well as the calibration model **210** to the calibration engine **206**. The calibration engine **206** can then determine, typically at the end of the calibration process, whether and how to modify the calibration model **210** so that the activity application **202** is able to more accurately interpret the activity sensor data **208**. In other words, the calibration engine **206** operates to cause the calibration model **210** to be modified so as to better fit the characteristics of the user of the electronic device. Either the calibration engine **206** or the activity application **202** can change the calibration model **210**. Thereafter, the activity application **202** is able to provide more accurate activity monitoring.

FIG. **3** is a flow diagram of a multi-speed calibration process **300** according to one embodiment of the invention. The multi-speed calibration process **300** is, for example, performed by an electronic device, such as the portable media device **102** illustrated in FIG. **1**. More particularly, the multi-speed calibration process **300** can be performed by the activity monitoring system **200** illustrated in FIG. **2**.

The multi-speed calibration process **300** begins with a decision **302**. The decision **302** determines whether an activity monitoring system is to be calibrated at a slower pace. In this embodiment, the activity monitoring system can be calibrated at a slower pace as well as a faster pace. Typically, the pace pertains to walking or running that is performed by the user during a calibration process. When the decision **302** determines that the activity monitoring system is to be calibrated at a slower pace, calibration is performed **304** to modify a calibration model. The calibration model being modified is either a default calibration model or a previously determined calibration model.

Following the block **304**, or following the decision **302** when the activity monitoring system is not to be calibrated at a slower pace, a decision **306** determines whether the activity monitoring system is to be calibrated at a faster pace. When the decision **306** determines that the activity monitoring system is to be calibrated at a faster pace, calibration is performed **308** to modify the calibration model.

Following the block **308**, or following the decision **306** when the activity monitoring system is not to be calibrated at a faster pace, the activity monitoring system is operated **310** in accordance with the modified calibration model. Typically, following calibration, the calibration model is improved as compared to the calibration model prior to such additional calibration. As a result, the activity monitoring performed by the activity monitoring system is more accurate. For example,

when the activity being monitored is walking or running, the activity monitoring system using the modified calibration model is able to more accurately determine characteristics of the walking or running, such as distance traveled, pace, etc.

The multi-speed calibration process **300** indicates that calibration can be performed at not only a slower pace but also a faster pace. The advantage of calibrating at a slower speed as well as a faster speed is that the calibration becomes more accurate and thus more reliable. However, it should be understood that in some embodiments, only one calibration need be performed. It should also be understood that in some embodiments, a calibration at one pace could be performed at one point in time, and calibration at another different pace could be performed sometime significantly later (e.g., day, week or months later).

FIGS. **4**A and **4**B are flow diagrams of a calibration model improvement process **400** according to one embodiment of the invention. The calibration model improvement process **400** is, for example, performed by an electronic device, such as the portable media device **102** illustrated in FIG. **1**. More particularly, the calibration model improvement process **400** can be performed by the activity monitoring system **200** illustrated in FIG. **2**.

The calibration model improvement process **400** begins with a decision **402** that determines whether a calibration request has been received. In one embodiment, the calibration request can be initiated by a user of the electronic device. When the decision **402** determines that a calibration request has not been received, the calibration model improvement process **400** awaits such a request. On the other hand, when the decision **402** determines that a calibration request has been received, the calibration model improvement process **400** continues. In other words, the calibration model improvement process **400** is effectively invoked when the calibration request is received.

When the calibration model improvement process **400** continues, a user entry of a calibration distance is received **404**. As an example, the user can interact with a user interface of the electronic device to enter or select a calibration distance (i.e., predetermined calibration distance). A decision **406** then determines whether calibration has been started. For example, the user of the electronic device can initiate calibration through user action, such as via the user interface of the electronic device. When the decision **406** determines that calibration has not been started, the calibration model improvement process **400** awaits start of the calibration.

Once the decision **406** determines that calibration is to be started, an elapsed distance is set **408** to zero. The elapsed distance is the distance that the user covers during the calibration process. The calibration process is typically associated with a walk or run by the user. Hence, the elapsed distance can thus be a distance to be run or walked during the calibration process.

Next, a decision **410** determines whether there is new activity data. The activity data, as noted above, with respect to FIG. **2**, can be provided by an activity sensor that is separate from the electronic device (e.g., the portable media device **102**). When the decision **410** determines that new activity data is present, a contact time is extracted **412** from the new activity data. Contact time is the time that the user's shoe is in contact with the ground as the user runs or walks. Using the contact time, estimates of current pace and elapsed distance can be updated **414** during the calibration process. The calibration model is used to acquire the current pace and elapsed distance from the new activity data (e.g., contact time).

A decision **416** then determines whether the pace for the calibration process, i.e., walk or run, is too varied. When the pace is determined to be too varied, then the calibration process is deemed unreliable. Hence, in such case, the calibration process is aborted **418**. Alternatively, when the decision **416** determines that the pace is not too varied, a decision **420** determines whether a calibration complete indication has been received. In one embodiment, a user can interact with the electronic device to initiate a calibration complete indication. For example, the user can interact with the electronic device to signal that a predetermined calibration distance has been run or walked. In any case, when the decision **420** determines that a calibration complete indication has not been received, the calibration model improvement process **400** returns to repeat the decision **410** and subsequent blocks so that new activity data can be similarly processed.

On the other hand, when the decision **420** determines that a calibration complete indication has been received, an accuracy ratio is determined **422** based on actual distance and estimated elapsed distance. The actual distance is the distance the user ran or walked for the calibration process. Typically, the actual distance is the predetermined calibration distance that is chosen in block **404**. For example, one common calibration distance is 400 meters, since such can be readily found at a 400 meters oval track. The estimated elapsed distance is the accumulated elapsed distances during the calibration process (block **414**) as acquired using the electronic device.

Next, a decision **424** then determines whether the accuracy ratio is greater than (or less than) a threshold. In one implementation, the determination can determine whether the accuracy ratio is greater than a maximum threshold or less than a minimum threshold. These thresholds can be used to ensure that the accuracy ratio is not too excessive (e.g., too far from unity). A large or small accuracy ratio typically indicates that the calibration process was defective in some way. Hence, it is desirable to avoid using the data resulting from a calibration process that was defective. Hence, when the decision **424** determines that the accuracy ratio is greater than a threshold, the calibration process is aborted **418**. Alternatively, when the decision **424** determines that the accuracy ratio is not greater than (less than) a threshold, then the calibration model is modified **426** based on the accuracy ratio. Following the block **426** as well as following the block **418**, the calibration model improvement process **400** ends.

Although the calibration model improvement process **400** operates to receive a calibration request from a user to initiate the calibration process, it should be understood that in another embodiment, the activity data could be first captured and then subsequently a user could initiate the calibration process using the activity that was previously captured.

FIG. **5** illustrates a graph pertaining to walking calibration according to one embodiment of the invention. The x-axis of the graph is for ground contact time (Tc) in milliseconds (ms), and the y-axis of the graph is for pace (P) in minutes/mile. The graph plots a calibration model. The calibration model is a line defined by two points, a lower model point (M**1**) and an upper model point (M**2**). The solid line represents an existing calibration model. The dotted line represents a modified calibration model that results following the walking calibration. In one embodiment, the modification (e.g., modifying **426**) to the calibration model involves moving the upper model point (M**2**). The upper model point (M**2**) is moved left or right such that the ratio of the slope of the existing calibration line to slope of the modified calibration line is the same as the accuracy ratio (AR). The following equation is used to acquire the new upper model point (M**2**) for the calibration model:

$$Tc2a=(1-AR)*Tc1+AR*Tc2.$$

In effect, by moving the upper model point (M**2**) of the calibration model, the calibration pivots about the lower model point (M**1**). Although FIG. **5** pertains to walking calibration, the same calibration approach can be used for a running calibration. Preferably, the calibration lines for running and walking are separate lines.

In one embodiment, the user is recommended to perform a walking calibration and a running calibration. These different calibrations can be performed separately one after another on the same day or they can be performed many days apart. As an example, the walking calibration might move the upper model point (M**2**). In effect, by moving the upper model point (M**2**) of the calibration model, the calibration line pivots about the lower model point (M**1**).

Besides the calibration process illustrated in FIG. **5** in which one point of a line representing a calibration model is moved to render the calibration model more accurate, another calibration process can move more than one point (e.g., two points) of a line representing a calibration model.

FIGS. **6**A and **6**B illustrate graphs pertaining to running calibration according to one embodiment of the invention. The running calibration is done in two stages or legs. The user will run at different paces during the different stages or legs. One of the paces is deemed a faster pace, and the other of the paces is deemed a slower pace.

In FIG. **6**A, the graph illustrates calibration following a first stage or leg. The calibration process here is generally the same as that discussed above with reference to FIG. **5**. Typically, this leg would correspond to a slower pace run. In addition, the average contact time (Tc_leg**1**) for the first stage or leg is stored.

In FIG. **6**B, the graph illustrates calibration following a second stage or leg. In one embodiment, the modification (e.g., modifying **426**) to the calibration model involves moving both the upper model point (M**2**) and the lower model point (M**2**). The average contact time (Tc_leg**2**) for the second stage or leg is determined from the user performance (i.e., activity data) of the second stage or leg of the calibration process as generally discussed above with regard to determining the average contact time (Tc_leg **1**). If the average contact time (Tc_leg**2**) for the second stage or leg is too close to the average contact time (Tc_leg**1**) for the first stage or leg, then the average contact time (Tc_leg**2**) for the second stage or leg can be discarded and the calibration completed based on the calibration information for the first stage or leg.

On the other hand, if the average contact time (Tc_leg**2**) for the second stage or leg is not too close to the average contact time (Tc_leg**1**) for the first stage or leg, then the calibration process is completed using information from the second stage or leg. The lower model point (M**1**) is moved left or right such that the ratio of the slope of the existing calibration line to the slope of the modified calibration line is the same as the accuracy ratio (AR), while also insuring that the average contact time (Tc_leg**1**) for the first stage or leg remains on the modified calibration line. The following equations can be used to acquire the new lower model point (M**1**) for the calibration model:

$$Tc1b=(k*Tc\_leg1-AR*Tc\_leg2)/(k-AR), \text{ where}$$

$$k=(Tc\_leg2-Tc1)/(Tc\_leg1-Tc1).$$

In effect, by moving the lower model point (M**1**) of the calibration model, the calibration pivots about a point on the line that corresponds to the average contact time (Tc_leg**1**) for the first stage or leg. The calibration process can also check that Tc**1***b* is within reasonable range limits for contact

times. The reasonable range limits can be empirically determined from user population studies.

Once the new lower point (M**1**) is determined, the calibration process can determine a new upper point (M**2**) for the calibration model. The upper model point (M**2**) follows directly from the new lower point (M**1**) and the constraint that the "Tc_leg**1**" point be on the line. The following equations can be used to acquire the new upper model point (M**2**) for the calibration model:

$$Tc2b=(1-P2/P\_leg1)*Tc1b+P2/P\_leg1*Tc\_leg1,$$

where P_leg**1** is the pace corresponding to Tc_leg**1**. Hence, calibration following a second stage or leg serves to move both the lower model point (M**1**) and the upper model point (M**2**).

Another aspect of the invention pertains to a graphical user interface. The graphical user interface can be provided to assist a user in performing a calibration process (i.e., fine-tuning) the accuracy of the activity monitoring system. The graphical user interface can be provided on a display device of a portable electronic device that provides the activity monitoring system.

FIGS. **7**-**19** are exemplary screens that pertain to fine-tuning accuracy of an activity monitoring system. In FIG. **7**, a settings screen is illustrated with the "Shoes" item highlighted. Upon selection of the "Shoes" item, a shoes screen such as illustrated in FIG. **8** can be displayed. As shown in FIG. **8**, the "Fine-Tune" item is highlighted. When the "Fine-Tune" item is selected, a fine-tune status screen can be displayed such as illustrated in FIG. **9**. In this example, the fine-tune status screen indicates that a walk-type fine-tune was performed on Oct. 4, 2005 and that a run-type fine-tune was performed on Oct. 8, 2005. The "Pro Run" item is shown in the fine-tune screen as not having yet been performed. When the "Run" item is selected from the fine-tune screen such as illustrated in FIG. **9**, a fine-tune run screen such as illustrated in FIG. **10** can be displayed. From the fine-tune run screen, a user can select either a 400 meter run or a custom distance to be utilized for a fine-tune operation. Alternatively, the user could reset the fine-tune run data to its default data. When the fine-tune run screen is used to select the "Custom Distance" item as shown in FIG. **11**, a custom distance screen such as illustrated in FIG. **12** can be displayed so that a user can enter a custom distance to be utilized with respect to the fine-tune run.

The fine-tune screen illustrated in FIG. **13** shows the "Pro Run" item being highlighted. When the "Pro Run" item is selected, a fine-tune pro run screen such as illustrated in FIG. **14** is displayed. The fine-tune pro run screen allows the user to elect to run at a slower pace or a faster pace for the fine-tune operation. Regardless of which pace is selected, a fine-tune pro run screen such as illustrated in FIG. **15** is displayed. The fine-tune pro run screen illustrated in FIG. **15** allows the user to select a predetermined distance, a custom distance or a reset operation.

Once the fine-tune run has been specified, the user can be presented with a music selection screen and then a start screen. Once the user has indicated that they have started the fine-tune run, a workout status screen can be displayed as discussed above. When a pause request has been activated, such as by pressing a predetermined button, a fine-tune pause screen such as illustrated in FIG. **16** can be displayed. The fine-tune pause screen enables a user to end the fine-tuning or resume the fine-tuning. Regardless, when the fine-tune run has completed in a successful manner, a fine-tune run screen such as illustrated in FIG. **17** can be displayed. Alternatively, when the fine-tune run does not complete successfully, error

screens such as illustrated in FIG. **18** or FIG. **19** can be displayed. The error screen shown in FIG. **18** indicates that the distance run by the user was not the chosen distance for the fine-tuning. FIG. **19** indicates that the user varied their pace too much during the fine-tuning run, which caused inaccuracies.

Although the calibration models illustrated in FIGS. **5**, **6**A and **6**B utilize straight lines as calibration models, other calibration models could be utilized, such as calibration models that are curved or piecewise linear. In any case; in the event that a calibration model is unable to distinguish between multiple points, a stride time (Ts) can be utilized to discriminate between the multiple points on the calibration model. The stride time generally corresponds to the time period for a stride of a user (e.g., time period between successive heel contacts with the ground of a particular shoe).

Another aspect of the invention pertains to add to the storage of calibration data, such as a calibration model, at various locations within a system. For example, with respect to the sports monitoring system **100** illustrated in FIG. **1**, the primary storage location for the calibration model is the portable media device **102**. However, the calibration model can be stored at various other locations within the sports monitoring system **100**. For example, the calibration model can be stored in the personal computer **110**, the sports management server **118**, the sports device **104**, and/or the wireless interface accessory **106**. There are different advantages for storing the calibration model at different parts of the sports monitoring system **100**. Examples of the advantages for storing the calibration data at different parts of the sports monitoring system **100** are as follows. Since processing of activity data is normally performed at the portable media device **102**, storage of the calibration model in the portable media device **102** allows for efficient processing. Storage of the calibration model in the wireless interface accessory **106** is useful because it renders the wireless interface accessory **106** portable with respect to different portable media devices. As an example, the wireless interface accessory **106** could be coupled to a different portable media device and operate properly without having to perform any recalibration operations. Similarly, storage of the calibration model in the sports device **104** should enable the sports device **104** to be fully portable between multiple different devices that might utilize the activity data captured by the sports device **104**. Storage of the calibration model at the personal computer **110** can serve to provide backup storage for the calibration model as well as to permit processing of activity data at the personal computer. Storage of the calibration model at the sports management server **118** not only allows processing of activity data at the sports management server **118**, but also facilitates gathering information on accurate calibration models for different groups of users. Advantageously, by having access to calibration models of numerous users, the sports monitoring system **100** could improve a default calibration model that is initially provided with the system. With a default calibration model that is sufficiently accurate, subsequent calibration by a user can be less necessary, simplified or eliminated.

According to another aspect of the invention, calibration models can be influenced by one or more other considerations. Examples of the other considerations are shoe type, gender, weight, fitness level, surface type, and inclination of surface. These other considerations can affect the calibration model, whether as a default or as a personalized calibration model.

In one embodiment, the system can detect the type of shoe being utilized by the user. The type of shoe can affect the calibration model, such as depending upon the stiffness of the shoe soles. Other characteristics of the shoe can also affect the calibration model. One approach to detecting the shoe stiffness is to include an electronic component within the shoe that can be sensed by another device, such as the portable media device or an accessory device. These sensors can, for example, include RFID tags, magnetic elements, or optical (e.g., infrared).

FIG. **20** is an activity monitoring system **2000** for an electronic device according to another embodiment of the invention. The activity monitoring system **2000** is generally similar to the activity monitoring system **200** illustrated in FIG. **2** except that the activity application **202** further receives other sensor data **2002** in addition to the activity sensor data. The other sensor data **2002** can be used by the activity application **2002** when updating a calibration model **210**. In one embodiment, the other sensor data **2002** provides data that pertains to shoe stiffness or other shoe characteristics (e.g., male or female type shoe). It should be noted that updating includes selection of an appropriate one of a plurality of calibration models, such as when a plurality of calibration models for different shoes are provided.

Another approach to determining shoe stiffness would be for the user to perform a predetermined action while wearing the shoe with the sports device **104**. One type of predetermined action could pertain to the user jumping up and down. Besides these automatic approaches to determining shoe stiffness, in another embodiment, a user can manually interact with a user interface (e.g., such as a graphical user interface presented on a display of the user interface **204**). As an example, the user interface can facilitate a user entering an indication of the type of shoe or its stiffness. As particular examples, a user could enter (i) a shoe model name or number, or (ii) a stiffness code provided on the shoe. As still another particular example, the user could navigate though a series of displayable images so as to select the shoe they are using by visual means.

In one embodiment, the system can detect the surface the user is running or walking on. For example, a sensor in the shoe, such as the sports sensor **104** or other sensor, could capture data that can signal the type of surface on which the user is running. For example, analysis of the captured data can be used to determine whether the user is running/walking indoors on a treadmill or running outdoors. As another example, analysis of the captured data can be used to determine whether the user is running/walking on hard surfaces (such as paved roads) or less hard surfaces (such as grass or athletic tracks). The captured data can thus be used to modify or select the calibration model for the type of surface.

Additionally, according to another aspect of the invention, a calibration model can be customized in view of calibration information available from a remote source. For example, the calibration model utilized by the portable media device **102** can be customized using calibration information or parameters available from the sports management server **118**. For example, if the user of the portable media device **102** is also a user of the sports management server **118**, the sports management server **118** may know certain characteristics, traits or other information about the user. For example, a user may have previously informed the sports management server **118** of one or more of shoe type, gender, weight, and fitness level. To the extent such information is useful to customize or improve a calibration model for the user, such information can be provided to the personal computer **110** and/or the portable media device **102** and utilized to provide an improved calibration model.

Another aspect of the invention pertains to performing calibration in a staged or deferred manner. With staged cali-

bration, the calibration can be performed in parts. For example, a user may perform a walk calibration, which can lead to improvements to a default calibration model. Then, sometime later, the user can perform a run calibration at a slow pace that leads to further improvements to the calibration model. Still later, the user can perform a run calibration at a fast pace that can lead to still further improvements to the calibration model. Hence, as each stage of calibration is performed, the calibration model can be improved. However, none of the stages need be performed in any particular time or any particular order. Hence, the user is able to improve calibration as they have the time and interest to spend on calibration activities.

With deferred calibration, it is possible that the activity data that is transmitted by the sports device **104** to the wireless interface accessory **106** can be retained at any of a variety of different devices within the sports monitoring system **100**. For example, the activity data could be stored at the personal computer **110** or the sports management server **118**. By storing the activity data prior to its being processed with respect to a calibration model, such processing with respect to a calibration model can be performed sometime later when better and more accurate calibration models exist. This allows the devices of the sports monitoring system **100** to later reprocess activity data using improved calibration models. In other words, it allows after-the-fact processing of previously acquired activity data. This also allows analysis of a wide range of activity data across one or more calibration models.

Still another aspect of the invention pertains to merging different calibration models for the same user (e.g., same sports sensor **104**). As noted above, calibration models can be stored at various locations within a system. These calibration models, if different, can be merged. For example, if a first calibration model resulted from a more recent slow run calibration and a second calibration model resulted from a more recent fast run calibration, then the first and second calibration models can be merged for improved accuracy. The merging of the calibration models can be performed from the calibration models themselves and/or the calibration data that yielded such calibration models.

During a calibration process, the user typically runs or walks a predetermined distance. It is important that the user's pace during the walk or run remain somewhat consistent. Hence, another aspect of the invention is for a portable media device to monitor the user's pace during the calibration walk or run. To the extent the user is not walking or running at a substantially consistent pace, the portable media device can alert the user through audio and/or visual feedback that they need to increase or decrease their pace to maintain the substantially consistent pace that is sought for the calibration process. Also, if during or at the conclusion of the calibration process the system recognizes that the pace of the calibration walk or run was not substantially consistent, the user can be notified that the calibration process was defective. Normally, the calibration data acquired during a defective calibration walk or run would be discarded.

The various aspects, embodiments, implementations or features of the invention can be used separately or in any combination.

The invention is preferably implemented by software, hardware or a combination of hardware and software. The invention can also be embodied as computer readable code on a computer readable medium. The computer readable medium is any data storage device that can store data which can thereafter be read by a computer system. Examples of the computer readable medium include read-only memory, random-access memory, CD-ROMs, DVDs, magnetic tape, optical data storage devices, and carrier waves. The computer readable medium can also be distributed over network-coupled computer systems so that the computer readable code is stored and executed in a distributed fashion.

The many features and advantages of the present invention are apparent from the written description. Further, since numerous modifications and changes will readily occur to those skilled in the art, the invention should not be limited to the exact construction and operation as illustrated and described. Hence, all suitable modifications and equivalents may be resorted to as falling within the scope of the invention.

What is claimed is:

1. A method of automatically updating a user's calibration model, the calibration model being used by a user activity monitoring system, the method comprising:

receiving from the user a selected activity type to be performed by the user for updating the user's calibration model;

receiving an indication of a calibration distance;

in response to receiving a calibration start indication:

receiving current user activity data corresponding to a user's current activity type;

determining if the user's current activity type is consistent with the selected activity type based upon the user activity data;

notifying the user to change the user's current activity type to the selected activity type when the user's current activity data indicates that the current activity type is not consistent with the selected activity type;

in response to a calibration stop indication:

estimating at teat a distance based on the received user activity data and an existing user calibration model;

determining an accuracy ratio based on the calibration distance and the estimated distance;

modifying the user's existing calibration model only if the accuracy ratio is within a range of acceptable accuracy ratios and the activity data is consistent; and

using the user's modified calibration model to provide activity output data in accordance with the acceptable accuracy ratio.

2. The method as recited in claim **1**, wherein the activity type is selected from a group that includes at least a walking type of activity, a jogging type of activity, a running type of activity.

3. The method as recited in claim **1**, wherein the acceptable range of accuracy ratios is greater than a minimum accuracy ratio and less than a maximum accuracy ratio.

4. The method as recited in claim **1**, wherein receiving the current user activity data comprises periodically receiving the activity data.

5. The method as recited in claim **1**, wherein the estimate of at least the distance based on the received activity data and an existing calibration model further estimates a pace of the user based on the received activity data and the existing calibration model.

6. A non-transitory computer readable medium storing instructions for automatically updating a user calibration model used by an activity monitoring system during use activity, the instructions, when executed by one or more processors, are configured to cause the one or more processors to perform operations comprising:

receiving from the user a selected activity type to be performed by the user for updating the user calibration model;

receiving an indication of a calibration distance;

in response to receiving a calibration start indication:

receiving current user activity data corresponding to a user's current activity type;

determining if the user's current activity type is consistent with the selected activity type based upon the user activity data;

notifying the user to change the user's current activity type to the selected activity type when the user's current activity data indicates that the current activity type is not consistent with the selected activity type;

in response to receiving a calibration stop indication:

estimating at least a distance based on the received user activity data and an existing user calibration model;

determining an accuracy ratio based on the calibration distance and the estimated distance;

modifying the existing user calibration model only if the accuracy ratio is within a range of acceptable accuracy ratios and the user activity data is consistent; and

using the modified user calibration model to provide activity output data in accordance with the acceptable accuracy ratio.

7. The computer readable medium as recited in claim **6**, wherein the activity type is selected from a group that includes at least a walking type of activity, a jogging type of activity, a running type of activity.

8. The computer readable medium as recited in claim **6**, wherein the acceptable range of accuracy ratios is greater than a minimum accuracy ratio and less than a maximum accuracy ratio.

9. A method for modifying an operation of an activity monitoring system associated with a user, the activity monitoring system having a processor and a user interface, the method comprising:

receiving from the user a selected activity type to be performed by the user for the modifying an existing user calibration model;

receiving a calibration request and a calibration distance from the user interface;

receiving a calibration start indication;

in response to receiving the calibration start indication:

determining a current user activity type based upon current user activity data received from an activity sensor associated with the activity monitoring system;

determining if the current user activity is consistent with the selected activity type;

notifying the user to change the current user activity type to the selected activity type when the current user activity type is determined to not be consistent with the selected activity type;

generating an estimated distance based on the received user activity data and an existing user calibration model;

repeating the receiving user activity data from the activity sensor and generating the estimated distance until a calibration stop indication is received;

determining an accuracy ratio based on the calibration distance and the estimated distance;

modifying the existing user calibration model only if the accuracy ratio is within an acceptable range of accuracy ratios and the received user activity data is consistent; and

modifying the operation of the activity monitoring system based on the modified user calibration model.

10. An auto-calibrating system for monitoring a user's activity, comprising:

an interface adapted to receive (i) an indication of a calibration distance from the user of the activity monitoring system and (ii) a user activity type, the calibration distance and user activity type used to update a user's calibration model; and

a processor coupled to the interface, the processor adapted to execute programming instructions that are configured to cause the processor to perform operations comprising:

receiving a calibration start indication;

in response to receiving the calibration start indication:

receiving current user activity data corresponding to a user's current activity type;

determining if the user's current activity type is consistent with a selected activity type; and

notifying the user to change the user's current activity type to the selected activity type when the processor determines that the current activity type is not consistent with the selected activity type;

receiving a calibration stop indication; and

in response to receiving the calibration stop indication:

estimating at least a distance based on the received user activity data and an existing user calibration model;

determining an accuracy ratio based on the calibration distance and the estimated distance;

modifying the user's existing calibration model only if the accuracy ratio is within a range of acceptable accuracy ratios and the activity data is consistent; and

using the user's modified calibration model to provide activity output data in accordance with the acceptable accuracy ratio.

11. The auto-calibrating system as recited in claim **10**, wherein the range of acceptable accuracy ratios is greater than a minimum accuracy ratio and less than a maximum accuracy ratio.

12. The auto-calibrating system as recited in claim **10**, wherein the receiving activity data periodically receives the activity data.

13. The auto-calibrating system as recited in claim **10**, wherein estimating the distance based on the received activity data and an existing calibration model further estimates a pace of the user based on the received activity data and the existing calibration model.

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UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 9,137,309 B2
APPLICATION NO. : 11/585721
DATED : September 15, 2015
INVENTOR(S) : John Meron Ananny and Nicholas Robert Kalayjian

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

In the Claims

Column 14, Line 35; In Claim 1, delete "teat" and insert -- least --, therefor.

Column 14, Line 64; In Claim 6, delete "use" and insert -- user --, therefor.

Signed and Sealed this
Fifth Day of July, 2016

Michelle K. Lee

Michelle K. Lee
Director of the United States Patent and Trademark Office